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III. SMALL - SCALE CORONAL STRUCTURE

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BACKGROUND

This section is a review of recent observations and models pertaining specifically to solar coronal bright points (BPs) and more generally to small-scale coronal structure. We are primarily interested in addressing two questions: 1) What is the degree of correspondence among various alleged signatures of BPs at different levels of the atmosphere? and 2) What can BPs tell us about the emerging flux spectrum of the sun? In the following I first review older studies of BPs and then discuss the recent results presented at the Workshop.

BPs were first identified in coronal X-ray emission in 1969 (Vaiana et al., 1970), and their X-ray characteristics analyzed in detail during Skylab (see Golub, 1980 and Webb, 1981 for reviews). XBPs are compact (10-20 arc-sec) and short-lived (hours to a day), and at emergence are cooler ($\sim 1.8 \times 10^6$K) than regions that will become active regions (Little and Krieger in Webb, 1981). XBPs have been correlated with bipolar structures that appear on photospheric magnetograms as ephemeral regions (ER) (Golub et al., 1977). Bright point-like features are also visible in the chromosphere and transition region but at lower contrast (Harvey and Martin, 1973; Bohlin et al., 1975; Habbal and Withbroe, 1981); at these levels they are difficult to distinguish from bright network elements.

Golub (1980) emphasizes that the distribution of the number of coronal features emerging as a function of either size or lifetime is a monotonically decreasing function. An arbitrary statistical distinction has been made that regions living less than about one day are called BPs, and those living more than four days are called active regions.

Golub et al. (1977) showed that the lifetime of an XBP was linearly correlated with the bipole separation and total magnetic flux of its associated magnetic feature, which had fluxes $<10^{20}$ Mx. This single study, performed with Skylab-era data, was the basis for the argument that XBPs are the coronal signature of emerging flux in the quiet sun. This argument was based on the assumption that the bipoles associated with XBPs were ERs and, therefore, represented emerging flux. So, because XBPs are anticorrelated with the sunspot cycle such that the emerging flux spectrum is often dominated by small, short-lived structures (Davis, 1983), Golub (1980) has argued that the total average rate of flux emerging on the sun during the cycle is constant.

This suggestion has been disputed by Martin and Harvey (1979), Sheeley (1981), Harvey (1984), Martin et al. (1985) and Harvey (1985). Martin and Harvey (1979) and Harvey (1984) have shown that ERs tend to vary in phase with the solar cycle.

Martin et al. (1985) have suggested that there are two populations of XBPs, only one of which is associated with ERs and, therefore, emerging flux. Harvey (1984; 1985) suggests that HeI-λ10830 dark points (DPs), which also are anticorrelated with the sunspot cycle, are XBP proxies. Therefore, since HeI DPs are not typically associated with ERs, then XBPs will not typically be associated with emerging flux. Finally, Tang et al. (1984) and Harvey (1984) suggest that ERs are not just small emerging active regions, because the number of ERs emerging over a solar cycle is $\sim 10^3$ more than expected from downward extrapolation of the size distribution of active regions.

BPs and active regions also differ in such properties as latitude distribution, rotation rate, and magnetic orientation. BPs, ERs and short-lived (1-3 days) CaK plages have more uniform latitude distributions than active regions (Harvey and Martin, 1973), but ERs tend to peak in the active region zones at solar maximum (Harvey, 1984). Magnetic pores, which live 10-60 hours, also are more broadly distributed in latitude than sunspots. The pores and Ca regions may represent an intermediate form of emerging flux. Golub and Vaiana (1978) measured the rotation rates of regions living from 1 to 7 days, and found that the rate was a function of lifetime (or size), such that XBPs rotated more slowly than active regions.

It is important to establish whether or not BPs are rooted in the network. Older studies indicated that XBPs (Howard et al., 1979) and ERs (Harvey and Martin, 1973) were not obviously spatially correlated with the Ca network, unlike active regions (EFRs) which tend to emerge at the boundaries of supergranular cells (Bumba and Howard, 1965). If true, this again implies fundemental differences between BPs and active regions. However, short-lived Ca plages (Harvey and Martin, 1973) and bright Ca network elements (Muller and Roudier, 1984) tend, like XBPs, to be anti-correlated with the cycle. Further, using Skylab data, Egamberdiev (1983) recently showed that XBPs are spatially associated with Ca network boundaries.

In the Skylab images BPs were typically unresolved. But using Skylab X-ray and EUV images, Sheeley and Golub (1979) were able to resolve a BP into two or three small loops, each 2500 km in diameter and 12,000 km long. Using fine-grain film, Davis and Webb (1981) observed a flaring XBP loop that was only one arc-sec across and 12 arc-sec long.

Finally, Nolte et al. (1979) found that a significant number of XBPs "flared" just before disappearing, and Golub et al. (1974) estimated that about 10% of all XBPs flared during their lifetime. Marsh (1978) identified small Hα flares with ERs (i.e., "ER flares") and conjectured that they were associated with XBP flares. He demonstrated that the flares occurred when the ERs encountered the network boundary. Because some XBP flares are associated with macrospicules (Moore et al., 1977), or tiny filament eruptions, at least some XBPs may die following a catastrophic ejection of material. Hermans and Martin (1986 - this proceedings) suggest that small Hα filament eruptions and accompanying "miniflares" may be common in the quiet sun. And Brueckner and Bartoe (1983) described high velocity jets and explosive events observed in the EUV. Although the correspondences of these features is unknown, their frequency and explosive nature led Ahmad and Webb (1978) and Brueckner and Bartoe to speculate that such small-scale structures could supply the entire mass flux of the solar wind.

It is apparent that we have no clear observational understanding of the bright small-scale structure of the quiet sun. However, important results based on new observations of BPs have been obtained recently. Therefore, in this section we are most concerned with observations relating to the correspondences of coronal BPs with other features at lower levels of the solar atmosphere. This bias is reflected in the papers which follow this review. Seven of the 11 papers on small-scale structure describe observations of the correspondences among bright quiet-sun features. I summarize these new results in the next part, which ends with a list of 5 outstanding questions on BP correspondences which were formulated at the end of the Workshop. Finally, in the last part I review several recent observations and models relating to the heating mechanism(s) of BPs and other small-scale structures, and the possible influence of these structures on coronal heating.

RECENT OBSERVATIONS OF CORONAL BRIGHT POINT STRUCTURE

Microwave Observations

In the three papers which follow, Habbal and Harvey (1986), Kundu (1986) and Lang and Willson (1986) describe recent, independent VLA radio observations of small coronal structures which appear to have characteristics typical of coronal BPs. The observations at 2, 6 and 20 cm reveal compact ($10 \sim 40$ arc-sec) sources with $T_b \simeq 10^5$K and temporal variations over time scales of minutes. Emission at these wavelengths arises from the transition region and lower corona.

In the quiet sun at 6 cm (4.9 GHz) Marsh et al. (1980) found bright features associated with small bipoles and suggested that XBPs could account for a significant fraction of the quiet sun microwave signal. Recently, Habbal et al. (1986) observed with the VLA at 20 cm (1.45 GHz) three compact (20-40 arc-sec) structures which they considered to be coronal BPs. These structures exhibited spatial and temporal variations over time scales of minutes. Assuming free-free emission, Habbal et al. deduced magnetic field strengths of 50-100 G in the transition region -low corona of the BPs. However, their observations were somewhat compromised by the prescence of several large active regions on the disk.

Habbal and Harvey (1986 - this proceedings) present preliminary results of an improved set of BP observations at 20 cm with the VLA on 8 September 1985. No large active regions impeded these observations and about 20 BPs were detected on the disk. Simultaneous observations were obtained in HeI-λ10830, the photospheric magnetic field, Hα, OVIII (SMM) and in microwaves from Owens Valley. All of the microwave BPs corresponded to HeI dark points (DP) and magnetic bipoles; there were, however, more HeI DPs and bipoles than microwave BPs. In their related paper, Harvey, Tang and Gaizauskas (1986 - this proceedings) report that 7 of 11 (64%) of the 20 cm BPs corresponded to cancelling magnetic bipoles (see below) and only two with emerging flux. Variations in the emission of BPs at 20 cm and in HeI DPs were often, though not always, correlated on time scales of minutes, similar to the behavior of EUV BPs in the Skylab data (Habbal and Withbroe, 1981).

Kundu (1986 - this proceedings) presents two VLA observations at 6 and 20 cm from a large set of data acquired before and during the Spacelab-2 mission. Several BPs were detected with $T_b = 1.0- 3.6 \times 10^5$K and low degrees of polarization. In agreement with Habbal's results, the BPs corresponded to HeI DPs and bipoles. Kundu's

observations are important for the Spacelab collaboration discussed later as a test of the association between microwave BPs and EUV high velocity structures.

Finally, Lang and Willson (1986 - this proceedings) report on the first detections in the quiet sun at 2 cm (14.3 GHz) of small (5-25 arc-sec), variable, moving structures. Willson and Lang (1986) observed two highly polarized sources on 4 June 1984. More recently on 17 January 1986 2 cm sources with no measurable polarization were detected. One interesting possibility is that some of these sources arise from non-thermal gyrosynchrotron radiation. Such radio sources may be common, with a frequency of occurrence comparable to that estimated for XBPs, CIV jets and small eruptive filaments.

EUV and Visible Light Observations

Earlier I referred to the controversy surrounding the use of XBPs, ERs and HeI DPs as proxies of small-scale emerging flux on the sun. During the Workshop this subject was discussed in presentations by S. Martin, K. Harvey, L. Golub and myself. As reflected in the following papers, most of the present comparative studies of BPs involve the use of NSO-Kitt Peak HeI-λ10830 DPs as a proxy for coronal BPs. Harvey et al. (1975) first noted that many coronal features seen in soft X-rays also appeared in HeI-D3 and 10830 images. Subsequently, lacking routine X-ray observations, many researchers have used λ10830 images to detect coronal holes and BPs, which appear in HeI to be dark. This absorption is due to the enhanced population in the low corona of the triplet state of HeI, which absorbs the continuum radiation from below. However, the physical mechanism of this process is unknown. A popular suggestion is that excess XUV emission (λ <500 Å) excites the underlying HeI from the ground state. Since HeI is a chromospheric line, chromospheric features, such as the network, contribute to the signal, lowering the contrast for coronal features. For example, using λ10830 and X-ray rocket images, Kahler et al. (1983) showed that the detailed correspondence of the boundaries of coronal holes in the two data sets was poor. Such a comparison for XBPs and HeI DPs is being performed by L. Golub, K. Harvey and D. Webb, but has not been completed.

Harvey, Tang and Gaizauskas (1986 - this proceedings) report preliminary results of observations during six periods involving the simunltaneous comparison of HeI-λ10830 images and photospheric magnetograms with Hα, CIV, SiII, CaII and microwave data (see above). HeI DPs are associated with microwave and CIV emission and CaII blueshifts, but not on a one-to-one basis. Like XBPs, He DPs are associated with apparent magnetic bipoles, but more often with cancelling, opposite-polarity flux than with emerging flux (ephemeral regions) (see also Harvey, 1984; 1985; Martin et al., 1985). Also like XBPs, He DPs (Harvey, 1985) and mixed-polarity fields (Giovanelli, 1982) vary inversely with the solar cycle. Therefore, Harvey (1985) has suggested that coronal BPs are typically associated with chance encounters of existing flux (more mixed polarity) rather than with emerging flux.

This interpretation differs from that of Golub, Harvey and Webb (1986 - this proceedings). They compare near-simultaneous X-ray and magnetic data during four X-ray rocket flights, and find that XBPs were slightly more likely to be associated with emerging bipoles (ERs) than with chance encounters of existing flux. However, there was a less than 50% association between XBP and magnetic bipoles going in either direction; unfortunately only daily magnetograms were available to define the bipole evolutionary history.

Harvey, Tang and Gaizauskas (1986) also define two types of small-scale (10-30 arc-sec) HeI dark features: rapid darkenings with lifetimes of 10-30 min. associated with small ejecta, and longer lived (hours) darkenings which can exhibit large intensity variations over minutes. The ejecta are often associated with small surges and small filament eruptions (Hermans and Martin, 1986) and/or propagating "clouds". (Are these like the Skylab X-ray clouds described by Rust and Webb, 1977?)

During the Workshop, S. Martin reviewed the subject of small-scale magnetic fields with emphasis on recent observations at high spatial and temporal resolution obtained with the videomagnetograph (VMG) at Big Bear Solar Observatory (BBSO). The BBSO group has classified such structures by their place of origin (Martin, 1984) and by how they cancel or disappear (Livi et al., 1985). Quiet sun magnetic fields are of three main categories: ephemeral regions, network fields and intra-network fields. We earlier discussed ERs; ERs appear to be the primary form of bipolar flux emergence in the quiet sun, but they have short lifetimes. Network fields are thought to be residual fields from decayed active regions which have clumped around the bounderies of supergranules. These fields are involved in the large-scale diffusion of the global magnetic field. Finally, intra-network magnetic fields are representative of the continuous generation of magnetic field in the network cell interiors. These field fragments are swept to the boundaries of the supergranules and may be associated with the small-scale velocity field of the sun.

Martin and colleagues have classified the disappearance of small-scale flux by the origin of their components in the above three categories. They observe flux disappearance only through "cancellation" of opposite polarity fragments which come into contact. Cancelling flux loss is gradual, equal for both polarities, and occurs most frequently at the boundaries of the network. They conclude that cancellation is the dominant form of magnetic flux disappearance in the quiet sun. However, the physical mechanism(s) causing this flux loss remains unknown. Martin et al. (1985) suggest that XBP could be associated with both ERs and cancelling flux, the latter arising from heating associated with field line reconnection.

Figure 1 presents fine examples of the emergence of flux in an ER (within the oval starting at 1735 UT) and the cancellation of flux (within the two rectangles at top and bottom of each frame). These are BBSO VMG images courtesy of S. Martin. Note the separation with time of the opposite poles of the ER. Due to this expansion, the negative pole (black) of the ER encounters and cancels a small fragment of opposite flux.

Hermans and Martin (1986) report on results of a study of a new class of quiet sun activity which they call small-scale eruptive filaments. Like large filaments, these are chromospheric absorption features, but the small eruptives are common (about 1000 on the sun per day) and short-lived (average 70 min.). They are often associated with tiny patches of emission ("mini-flares"), HeI dark features and possibly cancelling flux.

Holt et al. (1986 - this proceedings) describe results of a study to measure the radial velocity in the chromosphere under coronal BPs. Their procedure was to measure the CaII-K line profiles of HeI DPs within and outside of coronal holes. They find that DPs not in coronal holes exhibit small blue-shifts of 0.1-1.2 km s^{-1},

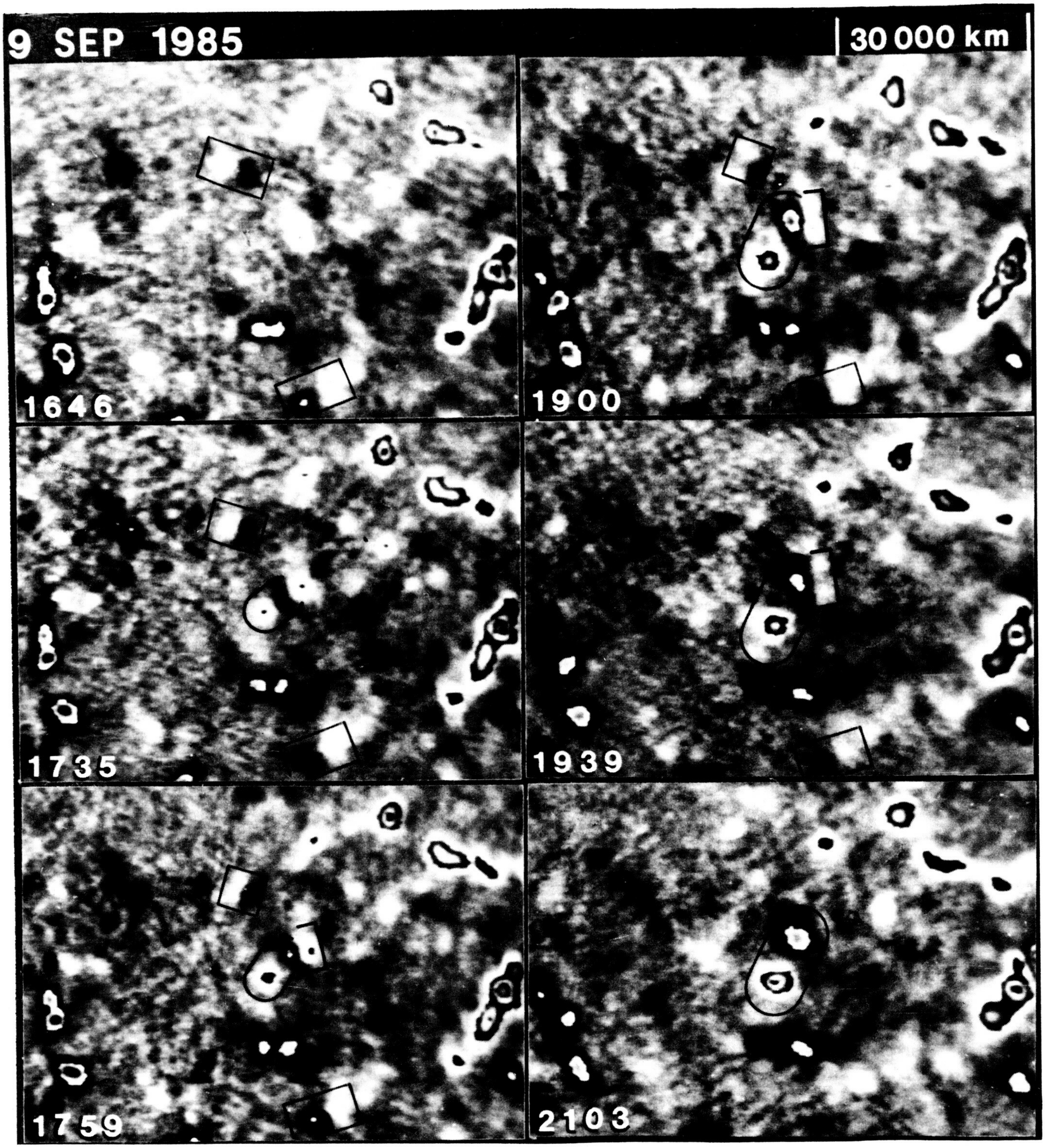

Figure 1

whereas 1/10 of the spectra of DPs within coronal holes have average blueshifts of 3.7 km s^{-1}. A collaborative study during the Spacelab-2 mission revealed that 4 of 5 HeI DPs had average blueshifts of about 1 km s^{-1}. These results lend some support to the speculation that coronal BPs and/or EUV jets might supply the mass flux in the solar wind. Small upward velocities in the chromosphere of a BP are not inconsistent with the observed velocities of $\sim$ 100 km s^{-1} in the low corona for macrospicules (Moore et al., 1977), XBP/polar plumes (Ahmad and Webb, 1978) and jets (Brueckner and Bartoe, 1983).

A wealth of high resolution EUV observations of the transition region, from experiments on Skylab, OSO-8, SMM, and HRTS, have become available in the last few years (e.g., Mariska, 1986). It is well known that the network in transition region lines is predominately redshifted. Using SMM CIV spectra, Gebbie et al. (1981) found a positive correlation between network intensity and redshift. Their plots showed a bimodal distribution, with the brightest sites having near-zero velocity. Toomre (private communication) speculated that these sites were the counterpart of coronal BPs. However, Athay et al. (1983) and Dere, Bartoe and Brueckner (1984) found no strong correlation between bright CIV network intensity and velocity.

Porter et al. (1986 - this proceedings) present recent results on temporal and spatial comparisons of similar SMM CIV images with magnetograms and HeI-λ10830 images. They find frequent intensity fluctuations at many bright CIV sites. All CIV BPs correspond to magnetic bipoles, and the longest-lived to HeI DPs. A comparison of the HeI and CIV intensity variations and velocity profiles is being performed.

Finally, during the Workshop G. Brueckner presented early results on explosive events and jets observed in CIV with the NRL HRTS instrument on Spacelab-2. More complete results have been presented at later meetings (Cook et al., 1986; Brueckner, Cook and Dere, 1986). CIV turbulent events and jets were first detected on HRTS rocket flights (Brueckner and Bartoe, 1983). These events were small (1-10 arc-sec), common, and Doppler-broadened to the blue, red or both by $\sim$ 100 km s^{-1}. To better establish the statistical importance of these events, 25% of the solar disk was surveyed in CIV during four orbits of the Spacelab-2 mission (see below). Initial examination of the film has revealed over 500 events with velocities $\geq$ 50 km s^{-1}. 35% of these events were blue-shifted (jets), 25% were red-shifted and 40% were both red and blue-shifted (turbulent or explosive events). The average velocity of each class was $\sim$80 km s^{-1}. Their average lifetime was 90 s, yielding a global birthrate of $\sim$40 s^{-1}. A global population of $\sim$4000 events at any time has been estimated.

Spacelab-2 Collaboration

In 1985 a collaboration was organized to coordinate groundbased and Spacelab-2 observations of coronal BPs. Valuable coordinated observations were obtained, but few results are available at this time. The major emphasis of the collaboration is on comparative analysis of near-simultaneous observations of BPs at all levels of the solar atmosphere, especially during the HRTS survey from 3 August, 2127 UT to 4 August 1985, 0253 UT. During this period 13 rasters in CIV and in the λ1190-1680 waveband were obtained; each CIV raster was about 1 arc-min N-S by 15 arc-min E-W, with 1 arc-sec step widths. Promising collaborative data obtained near or during this interval include photospheric magnetograms, HeI-λ10830 and D3 spectro-

heliograms, VLA images at 2, 6 and 20 cm, Hα images, CaK images and the CaK line profiles discussed by Holt et al. (1986). Although soft X-ray images were not obtained, this combination of data probably represents the best obtained to date for understanding the characteristics of BPs.

Summary of Observations of Bright Points

At the end of the Workshop we attempted to summarize our efforts by preparing a list of five questions which concern the correspondences of BPs, or other short-lived quiet sun features observed at all levels of the atmosphere. These questions are not comprehensive, but reflect our deliberations.

1) What is the relationship of BPs to emerging flux?

2) What is the correspondence of BPs, in the transition region and corona, to the network?

3) What is the correspondence of high velocity features, such as CIV jets, small eruptive Hα filaments, Hα and EUV macrospicules, XBP-polar plumes to BPs?

4) What is the correspondence of microwave BPs to other BPs?

5) Regarding the important HeI λ10830 observations:
   a. What is the correspondence of He DPs to other BPs?
   b. What is the chromospheric influence on HeI line formation?

Table 1 is a listing of the BP or small-scale features that have been observed and are discussed here along with correspondences with other features which have been made or inferred. The table is intended only as a general listing of BP features and their possible associations.

So what are BPs? The Skylab observations showed that the small, compact features seen in the corona could be traced downward in temperature and height to bipolar magnetic structures in the photosphere. These structures fluctuate in size and intensity on short time scales (minutes) and their fluctuations are often correlated at different heights. Therefore, these BPs appear to be magnetically controlled and probably consist of one or more tiny loops.

The physical correspondence to specific small-scale features in the intermediate chromosphere and transition region is more confusing and uncertain. It is particularly important to determine if BPs are associated with the network. We have but a single study (Egamberdiev, 1983) in which XBPs are purported to be correlated with the network. Microwave and CIV BPs are correlated with HeI DPs which in turn are more often associated with magnetic flux cancellation which in turn occurs more often at the boundaries of the network. And there is evidence that the occurrence frequency of bright Ca network elements oscillates out of phase with the sunspot cycle, like XBPs and HeI DPs. Spicules are another common transient feature which is spatially correlated with the network. Are BPs associated with spicules? On the other hand, magnetic ERs appear randomly with respect to the network (Harvey and Martin, 1973; Martin, 1984), but are associated with at least some coronal BPs. It is possible that there are actually several physical classes

TABLE 1

OBSERVED BP FEATURES AND SUGGESTED CORRESPONDENCES

Feature	Corresponding Features
XBPs	Ephemeral regions (emerging flux) Cancelling flux (Ca network) EUV BPs Polar plumes
Flaring XBPs	$H\alpha$ and EUV macrospicules
HeI DPs	Cancelling flux Ephemeral regions Microwave BPs CIV BPs Ca II blueshifts
Microwave BPs	Cancelling flux Ephemeral regions HeI DPs
CIV BPs	Magnetic bipoles HeI DPs
CIV eruptives/jets	?
$H\alpha$ small-scale filament eruptions	Mini-flares HeI DPs Cancelling flux

of BPs on the sun. It is also possible that these classes are a function of size and/or lifetime. In this context, it is important to realize that we have not yet detected the turnover at the short end of the lifetime (and size?) distributions of XBPs, ERs, HeI DPs or CIV transients.

To a large degree our present confused situation is due to a wealth of spacecraft observations in X-rays and the EUV, and the lack of coordinated efforts to compare results at different wavelengths. Hopefully, our understanding of BP structure will soon improve sufficiently to permit the development of detailed theoretical models of their structure, heating and energy balance.

THE INFLUENCE OF SMALL-SCALE STRUCTURES ON CORONAL HEATING

We formulated a final question: What is the structure and heating mechanism(s) of small-scale solar structure? In this part I review two aspects of this question. First, I discuss observations and a model pertaining to heating mechanisms of BPs. Then I address the fundamental question of the relationship of these small-scale structures to the heating of the corona.

Heating Mechanisms of BPs

Using Skylab data, Sheeley and Golub (1979), Nolte et al. (1979), Little and Krieger (in Webb, 1981), and Habbal and Withbroe (1981) studied the temporal behavior of individual BPs. Nolte et al. and Little and Krieger observed both rapid variations and steady output (over tens of minutes) in the integrated flux from different XBPs, while Sheeley and Golub and Habbal and Withbroe found that the intensity variations in BP emission typically varied over several minutes. In the latter studies the temporal behavior of a BP was found to be the average of the more rapid variations of individual loops. Even during periods of relatively constant integrated emission, individual loops were observed to form and disappear. Habbal and Withbroe found that the intensity variations were often temporally correlated at different heights. Both Nolte et al. and Habbal and Withbroe attributed these variations to intermittent heating of individual loops, sometimes impulsively.

In agreement with these earlier results, Habbal et al. (1986) have found that microwave BPs exhibit spatial and temporal variations over time scales of $\geqslant 2$ min. Habbal and Harvey note that these microwave BP variations are often, though not always associated with HeI DP variations. Since the EUV and microwave BPs and the HeI DPs vary frequently in shape and emission and since they are associated with cancelling magnetic flux, Habbal and Harvey (1986) conclude that the magnetic field is fundamental to this dynamic behavior. Both Habbal and Harvey and Lang and Willson (1986) suggest that the BP variability might be caused by varying magnetic fields or density variations related to intermittent heating.

Porter et al. (1986) observed strong fluctuations in CIV intensity overlying magnetic bipoles. They considered this as evidence that small-scale impulsive heating is common in the quiet sun transition region and in active regions (Porter et al., 1984), but not always associated with coronal emission (BPs). They attributed this to a stochastic process involving the convective motion of loop footpoints which results in field line reconnection and impulsive heating events.

Klimchuk, Antiochos and Mariska (1986 - this proceedings) discuss a model of the heating of small-scale (i.e., low-lying) coronal loops, with implications for BPs. Recently, Antiochos and Noci (1986) demonstrated that low-lying static loops have both hot and cool solutions. Linear perturbation theory suggests that hot loops are thermally unstable while cool loops are thermally stable. This implies that small, cool loops should be more abundant than hot loops, and small coronal loops, like BPs, should be short-lived, even for steady-state heating. Klimchuk et al. (1986) extend this analysis by performing non-linear, numerical simulations of such structures and find that both hot and cool loops appear to be stable and, therefore, both may be common in the low corona.

Small-Scale Structure and the Heating of the Corona

It has been determined that the energy flux due to the upward propagation of acoustic waves is 2-3 orders of magnitude too small to heat the transition region and corona (Bruner, 1981). Since this result appeared, researchers have speculated on whether the energy in radiation and mass flows of small-scale structures is sufficient to heat the corona. Such features must be sufficiently common at all phases of the cycle, individually energetic and globally distributed

so as to meet the mass and energy input requirements at the base of the corona (e.g., 4 X 10^5 erg $cm^{-2}s^{-1}$: Withbroe, 1977). Chromospheric spicules and EUV jets have been proposed as ubiquitous small-scale structures which meet these requirements. In addition, spicules, jets and XBP have been proposed as agents for providing the mass flux in the solar wind.

The upward mass flux in spicules exceeds the solar wind mass flux by about a factor of 100. Thus, infalling spicule material provides a large reservoir of potential energy that could heat the transition region and corona (Athay and Holzer, 1982). Brueckner and Bartoe (1983) suggested that EUV jets could heat the corona through shock wave heating or thermalization in confining magnetic fields. However, the recent Spacelab-2 data do not support the argument that the jets can provide sufficient energy flux to heat the corona.

Another approach to the coronal heating problem is suggested by the results of Orrall and Rottman (1986 - this proceedings). They examined the electron density "irregularity" of the inner corona by comparing EUV emission line intensity from coronal ions with K-coronal polarization brightness, pB. Since coronal emission depends on the square of the electron density and the scattered K-coronal brightness depends directly on the density, the combined observations constrain the density irregularity and include contributions from both resolved and unresolved structure along the line of sight. Orrall and Rottman develop models of the irregularity and find that it is too large to be explained by presently known inner coronal structures. They suggest that the irregularity might arise from unresolved small-scale structures possibly in instabilities or density fluctuations associated with coronal heating. It should be possible to pursue this question with two existing data sets of simultaneous AS&E soft X-ray ($f[N_e^2 dl]$) and HAO white light ($f[N_e dl]$) eclipse images (e.g., Krieger, 1977).

Finally, Schatten and Mayr (1986 - this proceedings) describe a model for coronal heating via spicules. Although they agree with others that spicules do not carry sufficient kinetic energy to heat the corona, they suggest instead that spicules are conduits which transport non-potential magnetic and wave energy into the solar atmosphere from the convection zone. This energy is then explosively released to heat the corona and possibly form an expanding solar wind.

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